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BENEFICIATION OF HIBERNIA SAND FROM GRAND BANKS, NEWFOUNDLAND

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by

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SUMMARY

A limited study of marine sand from the Hibernia oilfield, off-shore Newfoundland, was undertaken at the request of the Departmental Committee on Ocean Mining.

The four samples investigated were generally similar and essentially consisted of quartz with minor feldspar, garnet and ferro-magnesian minerals.

Processing, which included magnetic separation and froth flotation, removed a substantial percentage of the impurities, however, the resulting sand was not of "glass grade" quality. This sand could be utilized as general construction sand, in concrete, and as foundry moulding sand.

L'ENRICHISSEMENT DU SABLE HIBERNIA DES GRAND BANCs À TERRE-NEUVE

par

P.R.A. Andrews et G.A. Brown

RÉSUMÉ

On a entrepris une étude limitée du sable marin du gisement pétrolifère d' Hibernia, au large des côtes de Terre-Neuve, à la demande du Comité ministériel sur l'exploitation des ressources hauturières minières.

Les quatre échantillons analysés étaient semblables et étaient constitués essentiellement de quartz et de quelques fragments de minerais de feldspar, de grenat et de minerais de ferro-magnesium.

Le traitement, qui comprenait la séparation magnétique et la flottation par moussage, a permis de retirer une part importante des impuretés. Toutefois, le sable ainsi obtenu n'était pas de qualité suffisante pour en faire du verre. Ce sable pourrait être utilisé comme sable de construction, pour faire du béton et pour faire des moules de fonderie.

INTRODUCTION

At the request of the Departmental Committee on Ocean Mining and as part of CANMET's study of domestic silica resources, a limited study of marine sand deposits from the Hibernia oil field area was undertaken. These deposits occur as 'sand waves' or ridges in the Grand Banks area off the coast of Newfoundland, the average thickness being 3 m.

SOURCE AND DESCRIPTION OF SAMPLES

The four samples evaluated in this study were obtained from a 'sand wave' at a depth of 85 m and supplied to the Non-Metallic Minerals section by Mr. R. MacDonald, CANMET's representative on the Ocean Mining Committee. These samples were designated as:

67A

68A

Pandora No. 5

Pandora No. 6

The samples, received in a wet state, were essentially composed of well rounded quartz grains with minor amounts of feldspar, garnet and ferro-magnesian minerals. Each contained coarse fragments of sea shells which were removed, after drying, by screening on a 600 μm screen. Sample 67A contained more calcite than the others. Very little -100 μm material was present.

SAMPLE PREPARATION AND PROCESSING

After drying and screening at 600 μm , each sample was subsequently riffled into approximately 600 to 800 g lots for further processing by magnetic separation and flotation. In addition, head samples were prepared from each sample for chemical, mineralogy and size analyses.

SIZE ANALYSIS

Approximately 100 g from each sample was screened from 600 μm to 100 μm using successive $\sqrt{2}$ series screens; the size analyses are presented in Table 1.

MINERALOGY

Oil immersion mounts were prepared and studied under a petrographic microscope but all minerals could not be identified because some were opaque. Polished sections were prepared and studied with a reflecting microscope. They were then submitted for analysis by scanning electron microscope to confirm mineral identities and to prepare photographs for image analysis.

MAGNETIC SEPARATION

Apart from one test on Sample 67A using the Carpc dry magnetic separator, magnetic separation was performed using the Jones wet high intensity magnetic separator at the maximum current setting of 25 amps.

Approximately 800 g from each sample was passed through the Jones to produce magnetic, non-magnetic and middling products which, after filtering and drying, were analysed for Fe_2O_3 and Al_2O_3 . The results are reported in Table 2.

FLOTATION

Removal of small quantities of liberated impurities by flotation is an efficient method of beneficiation. Because silica is the major constituent it is logical to float the impurities by reverse flotation leaving a pure quartz concentrate.

The procedure adopted for removal of impurities was based on the known response of the minerals to flotation. In this respect calcite is floated using oleic acid, and flotation practice has previously demonstrated¹ that

iron oxides and feldspar are best floated by first using petroleum sulphonate collectors to remove iron oxides followed by cationic flotation using amines to remove feldspar.

Previous cationic flotation studies on feldspar have always been conducted using HF as an activator for feldspar. Since HF is extremely hazardous, it was decided to try to float feldspar using standard amine collectors without HF. In addition, the collector Duomeen TDO (n-tallow-1,3 - diaminopropane dioleate) was used, since it is selective for feldspar².

Based on the above, the following general procedure was adopted:

- Stage 1** Calcite flotation using an Oleic acid/Kerosene mixture at pH 7.
- Stage 2** Iron oxide flotation using Aerofloat 840 (natural petroleum sulphonate) at pH 3.5 to 5.0, employing high pulp density conditioning (~50% solids).
- Stage 3** Feldspar flotation using Armac T (tallow amine acetate), Armac C (coco amine acetate) and Duomeen TDO (n-tallow - 1,3 - diaminopropane dioleate) at pH 2.1 to 2.5, employing high pulp density conditioning (~50% solids).

The outlined procedure was used only as a guide, as in some tests certain stages were omitted as noted in the tabulation of reagent consumption in Table 3. With regard to calcite, there was insufficient mineral present in samples 68A, Pandora No. 5 and No. 6 to warrant a separate flotation stage. The sequence of stage 2 preceding stage 3 was used mainly in the later tests. During the earlier part of the test work experimentation was conducted mostly with the single collector system, that is, either Aerofloat 840 or one of the feldspar collectors was used to float both iron oxides and feldspar.

After calcite flotation and/or petroleum sulphonate flotation of iron oxides, the remaining quartz concentrates were filtered and washed twice to remove any residual flotation reagent before repulping and conditioning at ~50% solids. The pulp density was diluted to ~30% solids after conditioning and flotation conducted without further conditioning.

All products were filtered and dried following completion of the final flotation stage. Since only very small quantities of mineral were sometimes floated, it was decided to analyse only the quartz concentrates. The

resulting concentrate analysis, when compared to the flotation feed analysis, provided a good indication of the degree of success obtained in removing impurities.

Chemical analyses are reported in Table 4 and, conditioning and flotation times in Table 5.

RESULTS AND EVALUATION

MINERALOGY

The samples consist largely of colourless mineral grains with 1 to 5 vol % black grains. The colourless minerals are quartz, some feldspar and minor amounts of garnet. The feldspar is partly altered to kaolinite. It is estimated that quartz accounts for about 80 to 90 vol % of the minerals and is mostly present as free grains.

The black mineral grains are hematite, ilmenite, biotite and hornblende. The hornblende is partly altered to chlorite. In addition, a few separate chlorite grains are present.

MAGNETIC SEPARATION

The response to magnetic separation using both the Carpcu and Jones high intensity magnetic separator was similar. A rejection of 71.5% of the iron oxide minerals was obtained with the Carpcu compared to 65.9% with the Jones. Although complete removal of the iron oxides is not possible, quartz concentrate analyses between 0.08 to 0.10% Fe_2O_3 can be expected; the corresponding alumina level was slightly reduced, from a high range of 1.10 to 1.24% to a low range of 0.81 to 0.94% Al_2O_3 .

FLOTATION

Good selectivity was achieved with the collector Duomeen TDO as shown in the following summary of the best test results.

Sample no.	Test no.	Analysis %			Collector(s)
		SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	
67A	H5	98.97	0.256	0.073	Duomeen TDO
68A	H7	99.26	0.218	0.088	Armac T/Aerofloat 840
Pandora #5	H12	99.24	0.247	0.085	Duomeen TDO
Pandora #6*	H23	99.20	0.34	0.06	Aerofloat 840 followed by Duomeen TDO

* A separate petroleum sulphonate flotation stage was employed with this sample.

Sample 67A:

This was the only sample which contained calcite in sufficient quantity to necessitate a separate calcite flotation stage. Of the five tests performed on this sample, Test H5 using Duomeen TDO gave the best results. The following metallurgical balance shows the distribution of iron oxide and alumina.

Product	Weight %	Analysis %		Distribution %	
		Al ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃
Calcite float	0.9	6.42	9.32	5.63	31.80
TDO float	7.7	6.54	1.47	71.57	42.91
Qtz conc	91.4	0.256	0.073	22.80	25.28
Calcd head	100.0	(1.03)	(0.26)	100.00	100.00

This test demonstrates that 77.20% of the alumina minerals and 74.72% of the iron oxide minerals can be removed for an approximate recovery of 90% of the silica.

Sample 68A:

Only three tests were conducted on this sample due to the small quantity received. The best results obtained were Test H7 using Armac T combined with Aerofloat 840. These results, however, were obtained by floating an excessive amount of quartz, 29.9%. The reasons for this could be the excess quantities of collectors used, but this could not be investigated due to the small weight of sample, see Table 3.

Pandora #5:

Five tests were conducted using this sample and the best results were obtained for Test H12, using Duomeen TDO. The following metallurgical balance shows the distribution of iron oxide and alumina.

Product	Weight %	Analysis %		Distribution %	
		Al ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃
TDO float	14.4	6.27	1.76	81.03	77.68
Qtz conc	85.6	0.247	0.085	18.97	22.32
Calcd head	100.0	(1.11)	(0.33)	100.0	100.00

This test demonstrated that 81.03% of the alumina minerals and 77.68% of the iron oxide minerals can be removed for an approximate recovery of 85% of the silica.

Pandora #6:

Four tests were performed on this sample and the best results were obtained on Test H23 where a separate petroleum sulphonate flotation of the iron oxide minerals preceded the feldspar flotation using Duomeen TDO. Test H23 represented a reconstituted sample of middlings and non-magnetics from a Jones magnetic separation test. The following metallurgical balance provides a useful comparison between removal of iron oxides by magnetic separation and removal of iron oxides by flotation.

Product	Weight %	Analysis %		Distribution %	
		Al ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃
Non-magnetics	96.5	0.93	0.11	84.05	23.78
Sulphonate float	0.1	5.20	2.59	0.47	0.76
TDO float	7.3	8.41	0.34	56.05	7.32
Qtz conc	89.1	0.34	0.06	27.53	15.70
Calcd head	96.5	(0.90)	(0.08)	84.05	23.78

These results show that 23.78% of the iron oxide remained after magnetic separation. This was further reduced to 15.70% by flotation.

CONCLUSIONS

Each sample responded similarly to flotation, where quartz concentrates analysing between 0.218 to 0.377% Al_2O_3 and 0.06 to 0.088% Fe_2O_3 were obtained. These levels of alumina and iron oxide would allow use of this sand as foundry sand; they are too high for more specialized use such as in glass manufacture.

These results are based on a limited study because of the small quantity of sample received, and do not necessarily represent the optimum that could be obtained.

The simple flotation route is preferable to magnetic separation followed by flotation.

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Table 1 - Size analysis of sand samples

Size μm	67 A % Wt	68 A % Wt	Pandora #5 % Wt	Pandora #6 % Wt
+ 600	0.8	1.7	1.7	1.4
-600 + 425	5.4	6.0	6.1	6.1
-425 + 300	34.3	30.7	25.8	26.9
-300 + 200	44.7	44.0	44.9	46.2
-200 + 150	14.1	16.9	20.7	18.4
-150 + 100	0.7	0.7	0.8	1.0
-100	-	-	-	-

Table 2 - Magnetic separation assessment of sand samples

Sample no.	Method	Products	Weight %	Analyses (%)		Distribution (%)	
				Al ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃
67A		Head sample	100.0	1.10	0.33	100.0	100.0
	Carpco	Magnetics	2.0	7.03	11.30	14.0	71.5
		Non-mags	98.0	0.884	0.092	86.0	28.5
	Jones	Magnetics	2.3	4.32	8.41	10.5	65.1
		Middlings	31.8	0.99	0.14	33.2	15.0
		Non-mags	65.9	0.81	0.09	56.3	20.0
68A		Head sample	100.0	1.24	0.40	100.1	100.1
	Jones	Magnetics	1.5	3.55	7.71	5.7	54.8
		Middlings	33.4	1.00	0.13	35.6	20.6
		Non-mags	65.1	0.84	0.08	58.5	24.7
Pandora #5		Head sample	100.0	1.20	0.34	100.0	100.0
	Jones	Magnetics	2.2	4.69	7.95	9.7	67.3
		Middlings	33.7	1.08	0.10	34.0	13.0
		Non-mags	64.1	0.94	0.08	56.3	19.7
Pandora #6		Head sample	100.0	1.18	0.42	100.0	100.0
	Jones	Magnetics	3.5	4.87	9.43	16.0	76.2
		Middlings	32.7	1.05	0.12	32.1	9.1
		Non-mags	63.8	0.87	0.10	51.9	14.7

Table 4 - Flotation products - chemical analyses

Sample no.	Test no.	Analyses (%)						
		SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	LOI	Total
67A	Head sample	97.45	1.10	0.33	0.76	0.10	0.52	100.26
	Test H2	98.11	0.939	0.137	0.223	0.050	0.26	99.72
	Test H4	98.94	0.377	0.092	0.067	0.028	0.18	99.68
	Test H5	98.97	0.256	0.073	0.044	0.018	0.16	99.52
	Test H9	98.48	0.778	0.108	0.127	0.033	0.13	99.66
	Test H22*	99.09	0.48	0.10	0.03	0.02	0.22	99.94
68A	Head sample	97.52	1.24	0.40	0.24	0.10	0.25	99.75
	Test H6	98.07	1.003	0.140	0.170	0.044	0.19	99.62
	Test H7	99.26	0.218	0.088	0.038	0.020	0.18	99.80
	Test H8	98.27	1.018	0.187	0.164	0.051	0.18	99.87
Pandora #5	Head sample	98.24	1.20	0.34	0.25	0.10	0.20	100.33
	Test H10	98.38	0.989	0.119	0.161	0.043	0.14	99.83
	Test H11	98.29	1.008	0.137	0.168	0.049	0.16	99.81
	Test H12	99.24	0.247	0.085	0.040	0.026	0.17	99.81
	Test H13	98.69	1.003	0.102	0.147	0.036	0.17	100.15
	Test H17	98.93	0.490	0.090	0.12	0.02	0.19	99.84
Pandora #6	Head sample	98.19	1.18	0.42	0.28	0.11	0.19	100.37
	Test H14	99.15	0.42	0.10	0.16	0.03	0.18	100.04
	Test H15	98.83	0.53	0.11	0.16	0.03	0.17	99.83
	Test H16	98.51	0.60	0.08	0.16	0.02	0.24	99.61
	Test H23**	99.20	0.34	0.06	0.02	0.02	0.15	99.79

* Non-magnetic portion from the Carpc magnetic separation test.

** Combined middlings and non-magnetics from the Jones magnetic separation test.

Table 5 - Conditioning and flotation times

Sample no.	Test no.	Calcite flotation		Iron oxide flotation			Iron oxide & feldspar flotation		
		cond* min.	float min.	cond** min.	float min.	cond*** min.	cond.** min.	float min.	float min.
67A	H2								
	H4	6	4			4	4	4	3
	H5	5	4			4	4	6	
	H9	5	4			4	4	5	
68A	H22	5	3	4	4		4	4	
	H6						4	3	
	H7				4		4	2	2
	H8						4	4	
Pandora #5	H10						4	4	
	H11						4	4	
	H12			4	4		4	4	
	H13						4	4	
	H17	8	5				4	4	
Pandora #6	H14						4	3	
	H15						4	6	
	H16	5	5				4	4	
	H23					4	4	2	

* Conditioning and flotation were conducted at ~30% solids.

** Conditioning was conducted at ~50% solids and flotation at ~30% solids.

*** Conditioning with pH modifier only.

